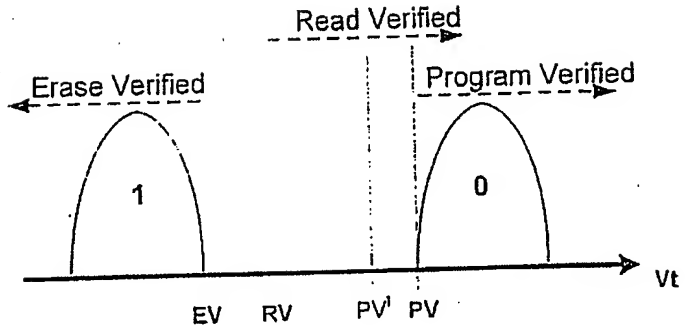
Read Verified
Erase Verified
Program Verified
1
0
Vt
EV
RV
PV'
PV

FIG 1A

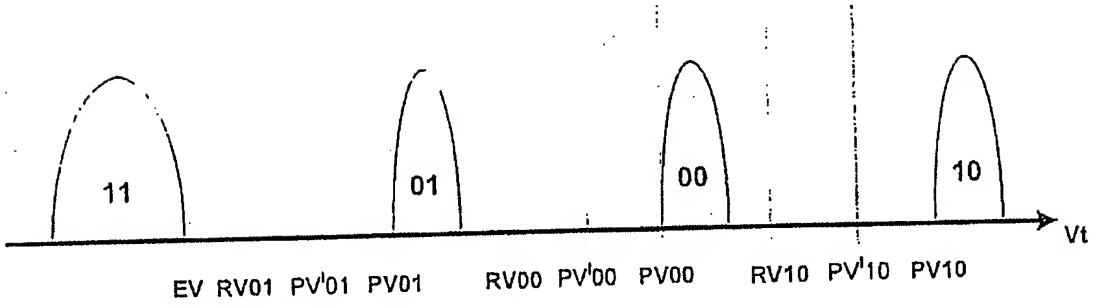
11
01
00
10
Vt
EV RV01 PV'01 PV01
RV00 PV'00 PV00
RV10 PV'10 PV10

FIG 1B

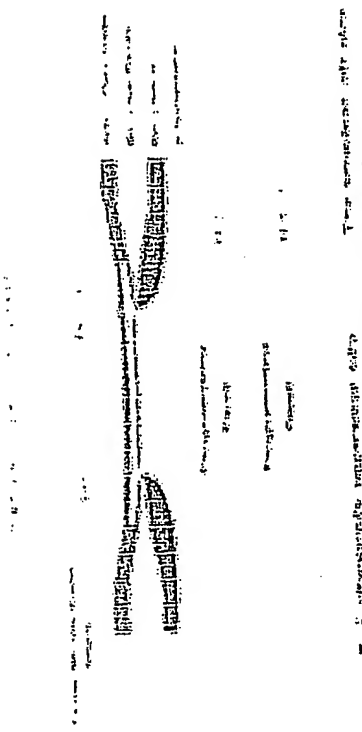

FIG. 2A

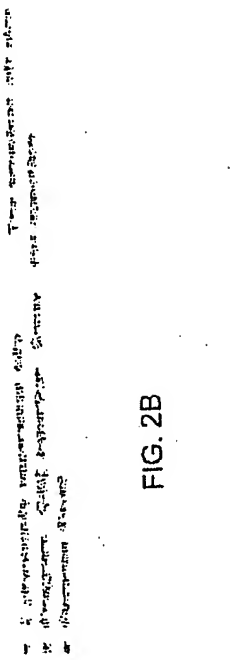

FIG. 2B

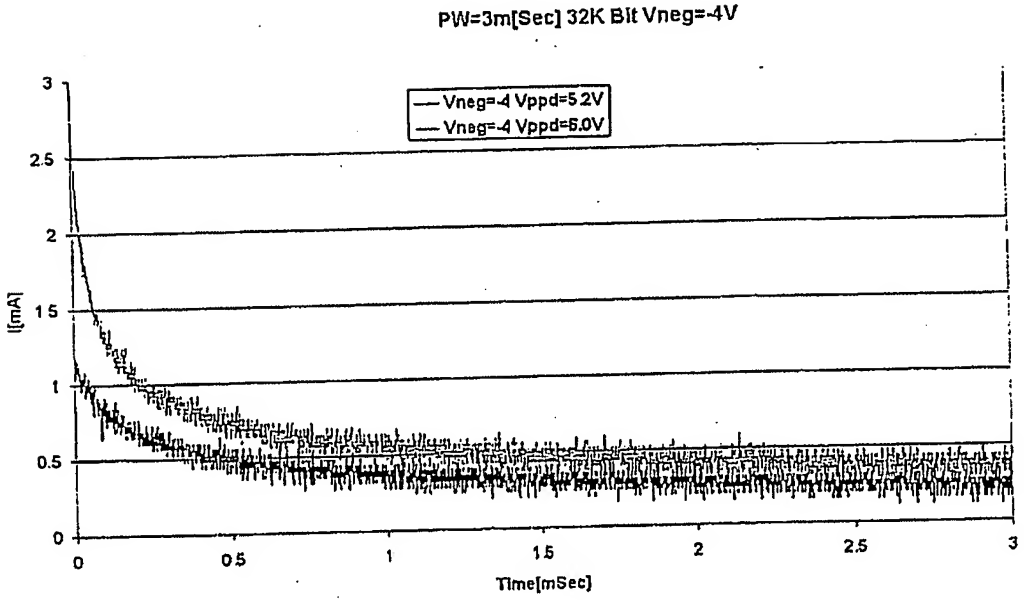
PW=3m[Sec] 32K Bit Vneg=-4V
Vneg=-4 Vppd=5.2V
Vneg=-4 Vppd=5.0V
I[mA]
Time[mSec]
0
0.5
1
1.5
2
2.5
3

FIG. 3

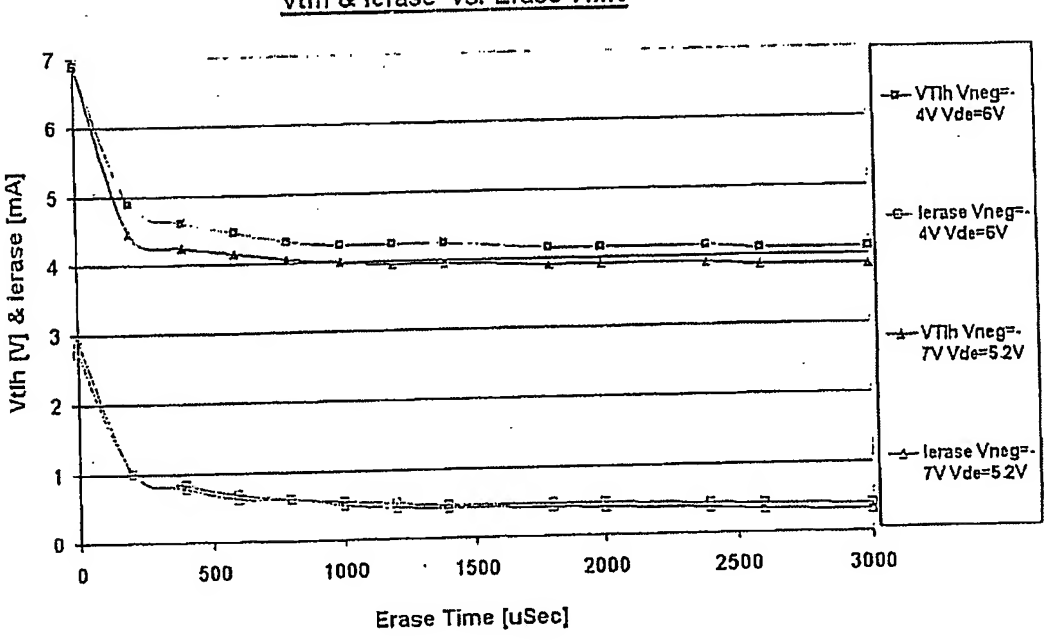
Vtlh & Ierase vs. Erase Time
Vtlh [V] & Ierase [mA]
Erase Time [uSec]
VTlh Vneg=-4V Vde=6V
Ierase Vneg=-4V Vde=6V
VTlh Vneg=-7V Vde=5.2V
Ierase Vneg=-7V Vde=5.2V
0
500
1000
1500
2000
2500
3000

FIG 4

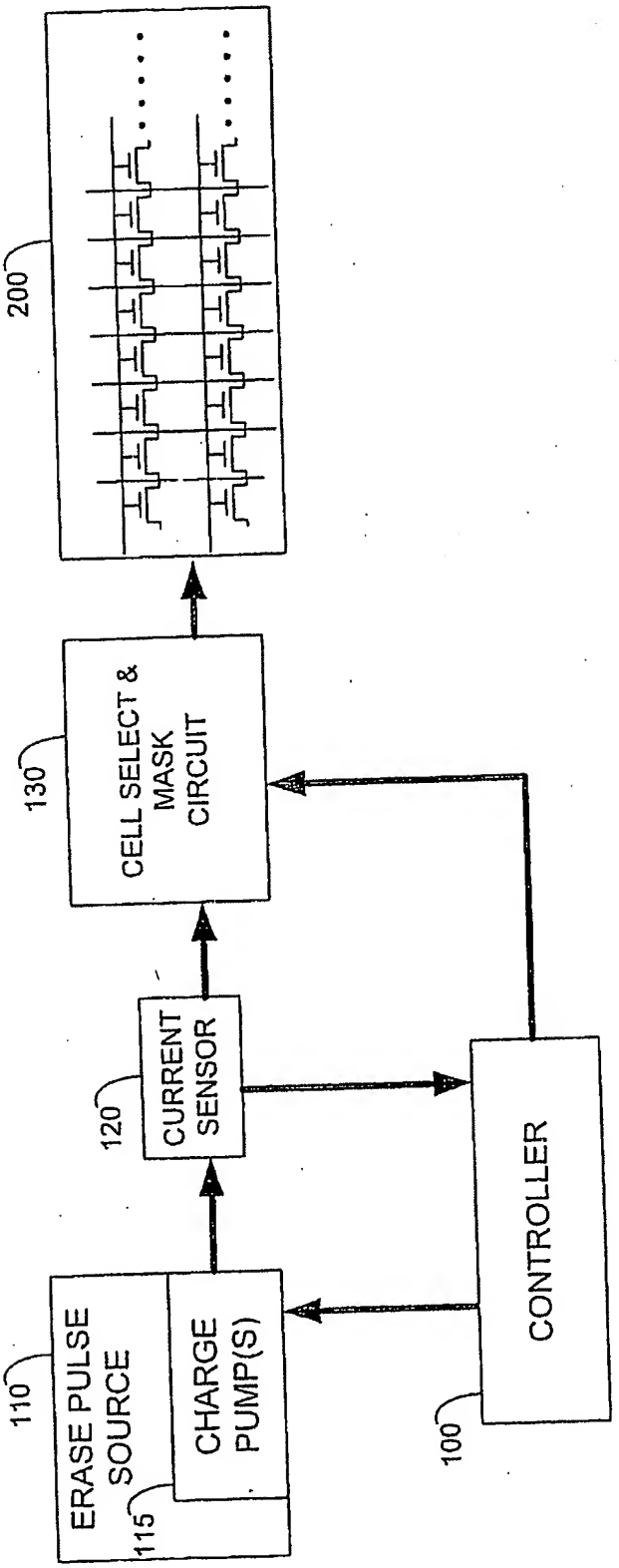
200
130
CELL SELECT & MASK CIRCUIT
120
CURRENT SENSOR
110
ERASE PULSE SOURCE
115
CHARGE PUMP(S)
100
CONTROLLER

FIG. 5

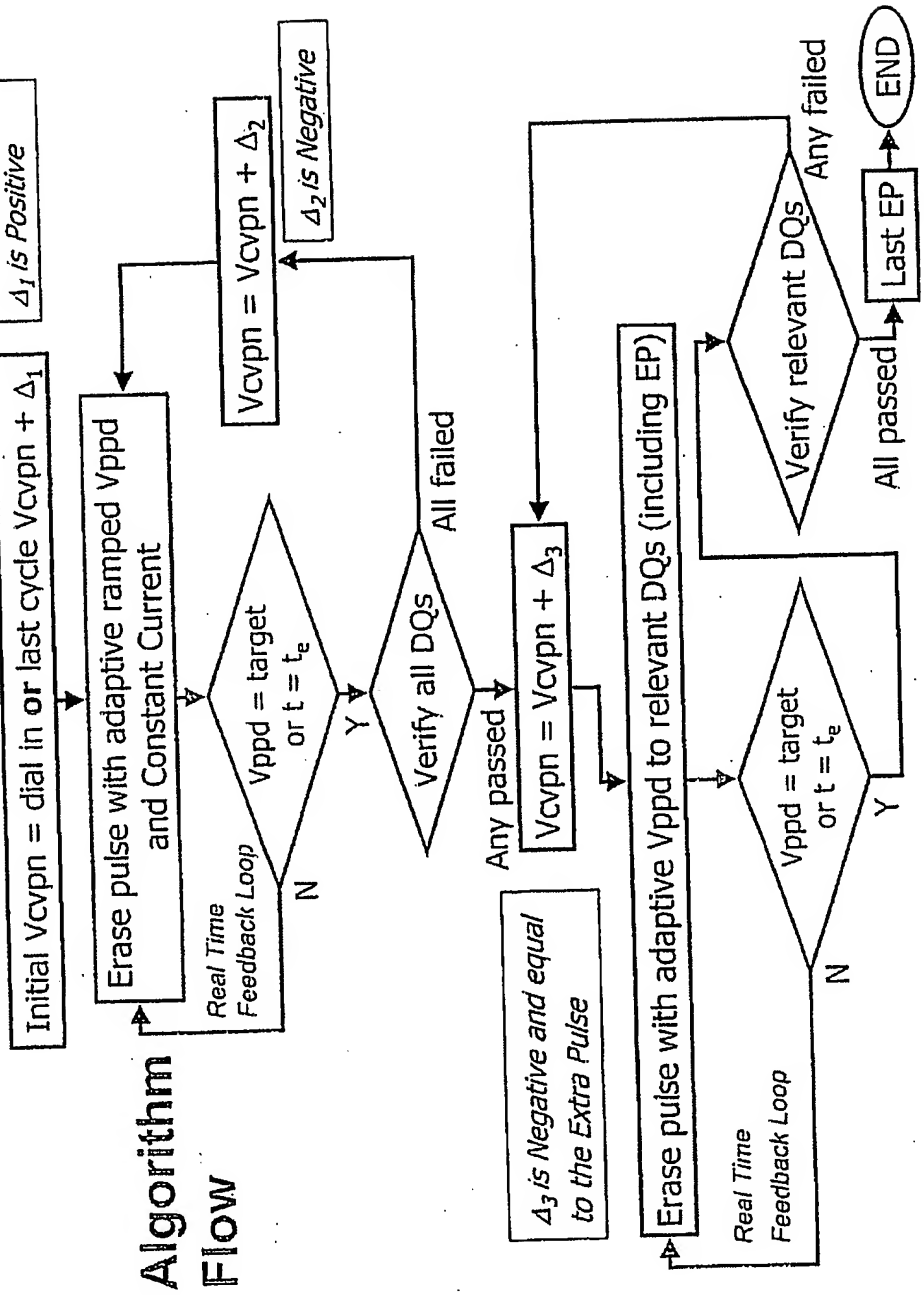
Algorithm Flow
Initial Vcvpn = dial in or last cycle Vcvpn + Δ1
Δ1 is Positive
Erase pulse with adaptive ramped Vppd and Constant Current
Real Time Feedback Loop
Vppd = target or t = te
N
Y
Vcvpn = Vcvpn + Δ2
Δ2 is Negative
Verify all DQs
All failed
Any passed
Vcvpn = Vcvpn + Δ3
Δ3 is Negative and equal to the Extra Pulse
Erase pulse with adaptive Vppd to relevant DQs (including EP)
Real Time Feedback Loop
Vppd = target or t = te
N
Y
Verify relevant DQs
Any failed
All passed
Last EP
END

FIG. 6

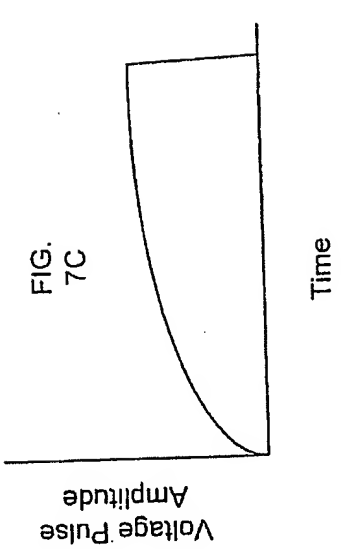
FIG. 7C
Voltage Pulse Amplitude
Time

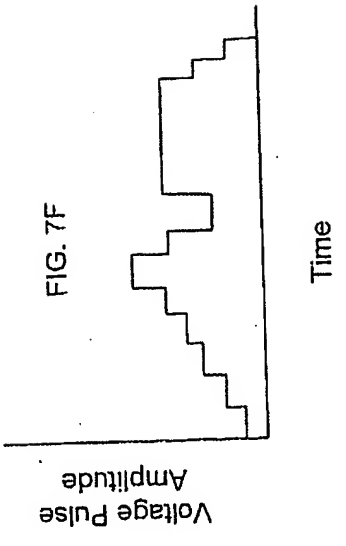
FIG. 7F
Voltage Pulse Amplitude
Time

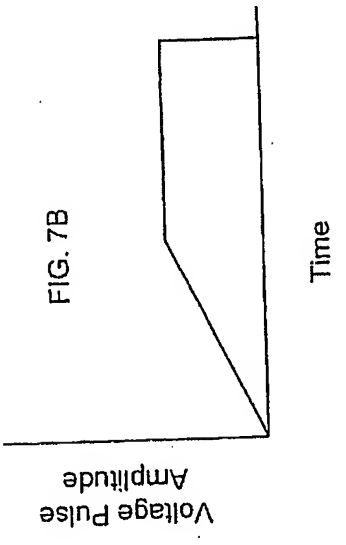
FIG. 7B
Voltage Pulse Amplitude
Time

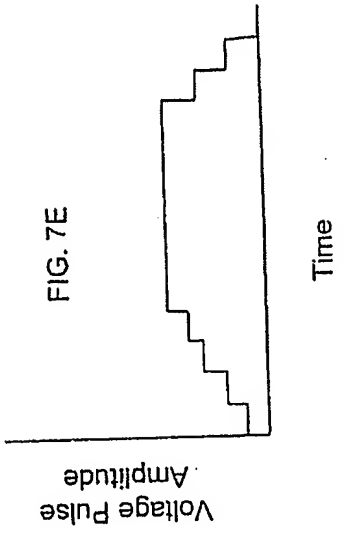
FIG. 7E
Voltage Pulse Amplitude
Time

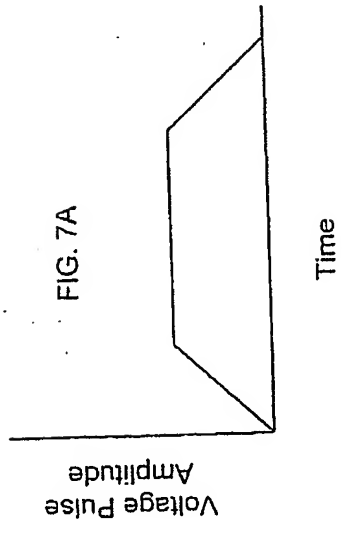
FIG. 7A
Voltage Pulse Amplitude
Time

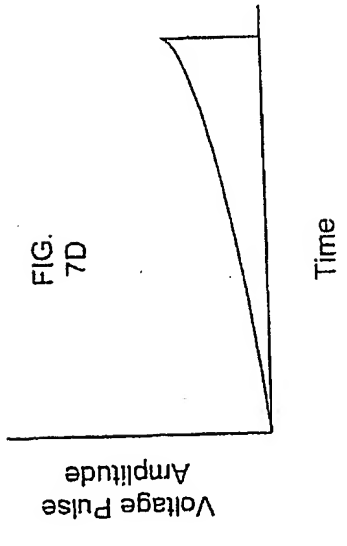
FIG. 7D
Voltage Pulse Amplitude
Time

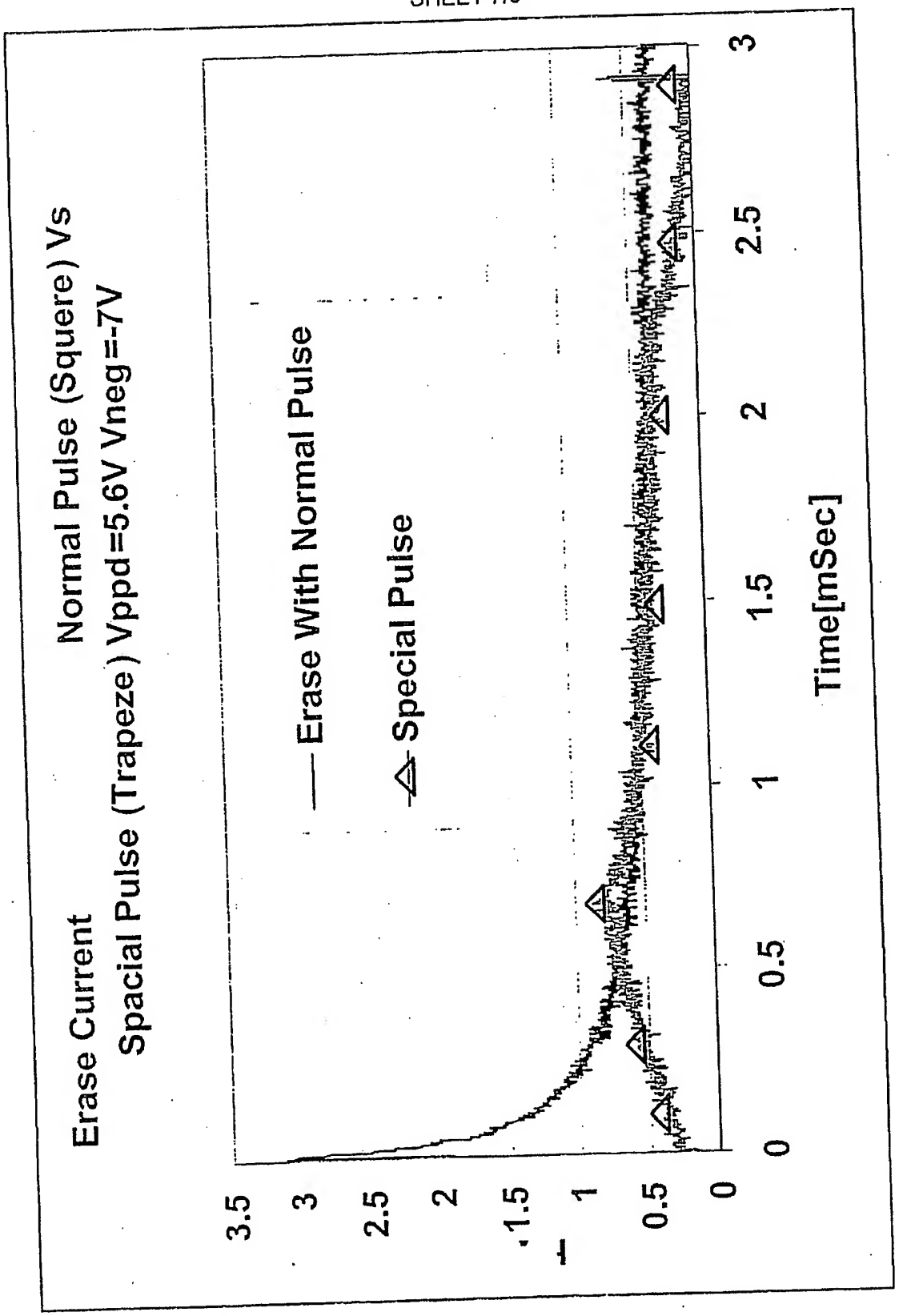
Erase Current
Spacial Pulse (Trapeze) Vppd=5.6V Vneg=-7V
Normal Pulse (Squere) Vs
Erase With Normal Pulse
Special Pulse
3.5
3
2.5
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
3
Time[mSec]

FIG. 8

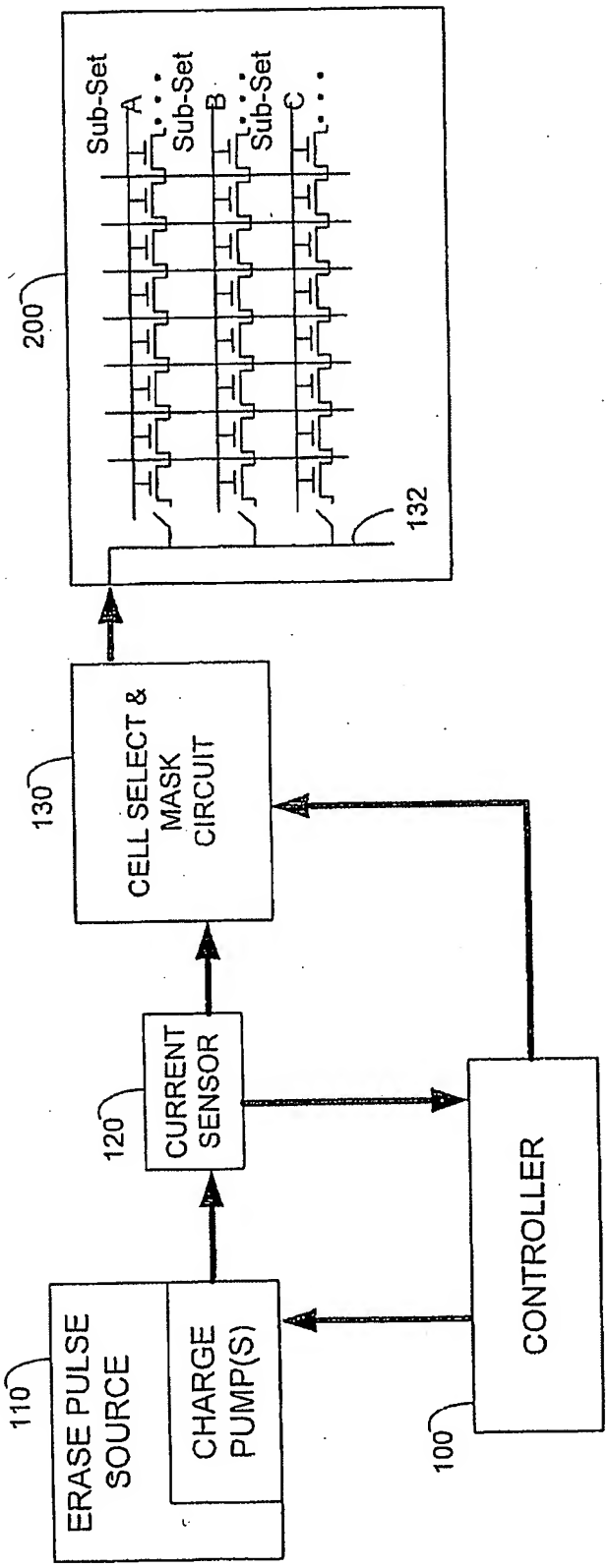
Sub-Set A
Sub-Set B
Sub-Set C
200
132
130
CELL SELECT & MASK CIRCUIT
120
CURRENT SENSOR
110
ERASE PULSE SOURCE
CHARGE PUMP(S)
100
CONTROLLER

FIG. 9

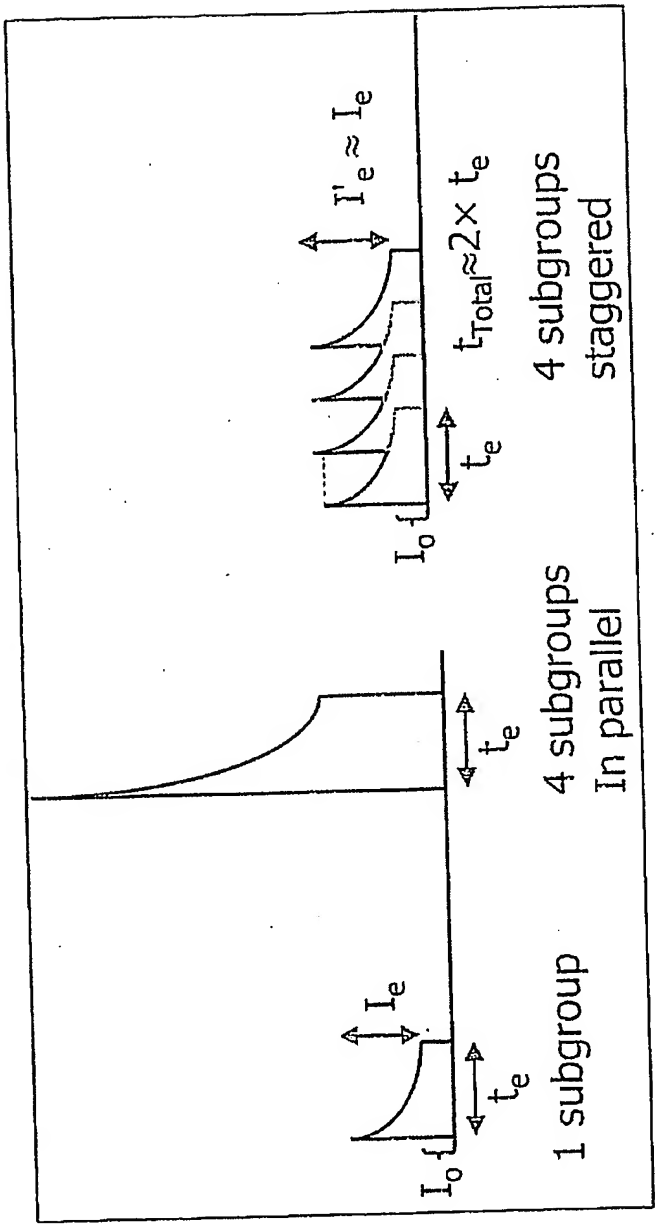
$I'_e \approx I_e$
$t_{Total} \approx 2 \times t_e$
t_e
I_o
4 subgroups
staggered
4 subgroups
In parallel
t_e
I_e
t_e
I_o
1 subgroup

FIG. 10